

Life History Characteristics of the Wood River Sculpin, *Cottus leiopomus* (Cottidae), in Idaho

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The Wood River Sculpin, *Cottus leiopomus*, is endemic to the Wood River basin in Idaho and is a nongame species of concern because of its limited distribution, but the status and biological characteristics of this species were previously unknown. We collected 716 *C. leiopomus* from ten populations across the Wood River basin from streams with a variety of physiochemical conditions to estimate length and age at sexual maturity and other demographic characteristics. Most *C. leiopomus* were estimated to be age-1 (16%), age-2 (33%), age-3 (30%), and age-4 (12%); the oldest was estimated to be eight years old. Estimated total annual survival rate was consistent across all study sites, averaging 66% and ranging from 56 to 70%. Survival was positively correlated with mean stream width and negatively correlated with stream gradient, although sample sizes for these comparisons were small and we are cautious in asserting a causative effect. Sculpin reached 60 mm total length by age-2 and reached 100 mm at around age-4; the largest *C. leiopomus* captured was 121 mm. Sex ratio was near 50:50 for most populations and averaged 51% female across all populations. Fecundity ranged from 38 to 314 eggs and formed a linear relationship with fish length ($r^2 = 0.67$). At the two sites where sampling occurred in the spring and maturity could be more definitively determined, almost all *C. leiopomus* age-3 and older were mature, regardless of gender. No age-1 fish were mature, and no age-2 males were mature, but 83% of age-2 females were mature. We estimated that females transitioned from immature to mature at about 55 mm and males at about 60 mm. These results are the first published data on the life history characteristics of *C. leiopomus* and provide useful information for the management and preservation of this species.

THE Wood River Sculpin, *Cottus leiopomus*, is endemic to the Wood River basin in Idaho, USA. It is a benthic species that inhabits flowing water from small streams to larger rivers and is often found in sympatry with native Redband Trout, *Oncorhynchus mykiss gairdneri*. This sympatry is likely due to similar requirements of clean, cool water and coarse substrate (gravel and larger) which stream-dwelling sculpin typically select for spawning and rearing (Bailey, 1952; Jones, 1972; van Snik Gray and Stauffer, 1999). The level of competition for food and space between *C. leiopomus* and *O. m. gairdneri* is unknown. Although *C. leiopomus* appears to be one of the most abundant species of fish in the Wood River basin (KAM, unpubl. data), it is recognized as a nongame species of concern by the Idaho Department of Fish and Game (IDFG, 2006) because of its limited range. Little is known of this species, and to our knowledge, there are no published accounts of the species' distribution, abundance, or population characteristics.

Our objective was to quantify several life history characteristics of *C. leiopomus*, including growth and mortality rates, longevity, length–weight relationships, and length- and age-specific fecundity and maturity. In addition, we collected data on stream characteristics in an attempt to assess what environmental factors might be correlated with these life history characteristics.

MATERIALS AND METHODS

The Wood River is a tributary of the Snake River in central Idaho, which is composed of three major sub-basins: the Big Wood River, Little Wood River, and Camas Creek. Several

migration barriers exist that have isolated fish in the Wood River basin. First, the river is not currently connected to the Snake River because a stretch of the river is continually dry, in large part because of percolation of surface water into the Snake River Aquifer but also because of irrigation diversion of surface water. However, before its confluence with the Snake River it reemerges as what is known as the Malad River. In addition, there is a 30 m waterfall on the Malad River about 5 km from the mouth which has created a long-term (i.e., tens of thousands of years) barrier to fish migration. Two dams with no fish passage further isolate fish in the basin: Magic Reservoir in the Big Wood River sub-basin (built in 1910) and Little Wood Reservoir in the Little Wood River sub-basin (built in 1939).

The basin covers 7,778 km² of semiarid valleys and mountainous headwaters ranging from 837 m to over 3,600 m in elevation. Precipitation is mostly in the form of winter snowpack and ranges from 18 cm in the lower valleys to 64 cm in the mountains. Discharge is driven by snowmelt and peaks between April and June, but is modified by numerous irrigation diversions in mainstem and tributary streams.

Field sampling.—Using backpack- and canoe-mounted electrofishing units, 733 *C. leiopomus* were collected from ten study sites during base flow conditions between July 2003 and February 2004 (Table 1). Most of the samples were collected during the summer, but two samples were collected in late winter prior to spring spawning in order to estimate maturity and fecundity (see below). Sample streams and the study sites within the streams were selected

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arbitrarily, but we purposefully distributed study sites across a broad geographic area in the Wood River basin in order to incorporate a variety of stream conditions (Table 1).

At each study site, sculpin abundance was estimated with depletion electrofishing (3–4 passes), using one or more backpack electrofishers with pulsed DC. Block nets were installed at the upper and lower ends of the sites to meet the population estimate modeling assumption that the sculpin populations were closed. Depletion sites were 70–120 m in length (depending on habitat types and ability to place block nets). The Big Wood River was too large to conduct depletion electrofishing, thus sculpin abundance could not be estimated at this study site.

Maximum-likelihood abundance and variance estimates were calculated with the MicroFish software package (Van Deventer and Platts, 1989). Because electrofishing is known to be size selective (Sullivan, 1956; Reynolds, 1996), sculpin were separated into two length categories, <60 mm TL and ≥60 mm TL; abundance estimates were made separately for these two size groups and summed for an overall estimate. Capture efficiency for sculpin <20 mm was low relative to larger fish, thus estimates for fish <60 mm were probably underestimated.

Captured *C. leiopomus* were overdosed with tricaine methanesulfonate (MS-222) at 250 mg/L and transported directly to a freezer for storage. If an adequate sample was not obtained from within the depletion reach, electrofishing continued in an upstream direction until a sufficient number of fish were captured and retained. Our goal was to retain 60–100 fish from each location for analyses of life history characteristics.

In addition to sculpin density, several other physical and physiochemical stream attributes were measured to assess their relationship to the life history characteristics of *C. leiopomus*. Selection of which stream characteristics to measure was based on their ecological importance, on previous research into factors generally related to fish growth as well as age and length at maturity, and on their ease of collection. We generally focused on variables we felt reflected stream size (e.g., stream order, width), fish growing conditions (e.g., elevation, conductivity), and microhabitat characteristics (substrate, depth, stream shading, unstable banks).

At each collection site, we determined elevation (in meters) from U.S. Geological Survey (USGS) 1:24,000 scale topographic maps using Universal Transverse Mercator (UTM) coordinates obtained at the lower end of the reach. Stream order (Strahler, 1964) was determined from a 1:100,000 scale stream hydrography layer. Gradient (%) was determined using the software package All Topo Maps Version 2.1 for Windows (iGage Mapping Corporation, Salt Lake City, UT); the distance (in meters) between the two contour lines that bounded the study site was traced (average traced distance was about 1 km), and gradient was calculated as the elevational increment between those contours divided by the traced distance. Conductivity (μS/cm) was measured with a calibrated hand-held conductivity meter accurate to ±2%.

Ten equally spaced transects were established throughout the sample site from which the remaining measurements took place. Stream width (m) was calculated from the average of all transect readings. Across the transects, depth was measured at 1/4, 1/2, and 3/4 distance across the channel, and the sum of the measurements was divided by

four to account for zero depths at the stream margins for trapezoidal-shaped channels (Platts et al., 1983; Arend, 1999). Percent substrate composition was visually estimated as the percent of substrate within one meter of each transect that was silt (<0.06 mm), sand (0.06–1.99 mm), gravel (2–63 mm), cobble (64–256 mm), boulder (257–4,096 mm), or bedrock (>4,097 mm). Percent unstable banks and stream shading were also visually estimated. All visual estimates were averaged across all transects for an overall mean for each study site.

Laboratory processing and analysis.—Sacrificed sculpin were thawed in the laboratory, blotted dry, and measured for total length (TL, nearest mm) and weight (nearest g). Sagittal otoliths were removed and stored dry in vials. To age fish, annuli were counted on otoliths that were viewed primarily dry or submersed in saline solution, with a dissecting microscope. Annuli were counted as the translucent zones when using reflected light (Patten, 1971), but otoliths were also viewed with transmitted light if annuli were difficult to discern with reflected light. Readers had no knowledge of fish length during readings, and otoliths were read at separate time periods. The same two readers aged all fish, and agreement between first readings was deemed satisfactory; for our ten study sites, the mean index of average error between readers (Beamish and Fournier, 1981) was 10.2%. Discrepancies between readers were resolved with additional readings, and results were discarded for those fish whose age could not be resolved ($n = 17$). All fish were considered one year old when they reached their first January.

Gender and maturity were determined by laboratory examination of the gonads. Ovaries were visually distinguishable from testes for *C. leiopomus* about 40 mm and larger (in general, fish below this size were not sexed). To evaluate sex ratio at each site, we calculated 95% confidence intervals (CIs) around the percentage of the population that was female, following Fleiss (1981); CIs not overlapping 50% indicated a statistically significant departure from a 50:50 ratio.

Maturity was determined only from the late winter samples collected on 28 February 2004, just before the presumed spawning period (Bailey, 1952; Gasser et al., 1981). Males were classified as immature if testes were opaque and threadlike and mature if they were thicker, fleshy, and cream-colored. Females were classified as immature if the ovaries were small and granular, and mature if they contained large, well developed eggs. To estimate fecundity, eggs were removed and counted from 47 gravid females. A linear regression was developed to predict fecundity (F) from fish length (TL) and age, and standardized residuals were investigated to remove outliers from the regression models (Montgomery, 1991).

We characterized the length and age at maturity (termed the maturity transition point, or MTP; see Meyer et al., 2003) for *C. leiopomus* from the spring sampling sites. For length at maturity, we used one of two methods. If there was no overlap between the largest immature and smallest mature fish, we selected the midpoint between the lengths of these two fish as the MTP. If there was overlap, we related fish length to maturity using logistic regression, using a binary dependent variable (0 = immature, 1 = mature), and selected the MTP as the fish length at which the probability of being mature was equal to 0.5. Separate estimates were developed for males and females because length at maturity

Table 1. Stream Attributes for Study Sites in the Wood River Basin, Idaho. NA is for data that was not available.

Stream name	Sample date	UTM Coordinates			Stream order ^a	Elevation (m)	Gradient (%)	Conductivity (µS/cm)	Width (m)	Depth (m)	Percent:					<i>Cottus leiopomus</i> density (no./m ²)
		East	North	Zone							Silt	Gravel	Cobble/boulder	Stream shading	Unstable banks	
Trail Creek	7/30/2003 ^b	715875	4844638	11	4	1871	1.2	342	6.8	0.21	1	44	34	10	0	1.2
Warm Springs Creek	7/31/2003 ^b	702601	4834873	11	4	1896	0.4	165	9.5	0.22	1	28	64	12	0	0.2
Soldier Creek	7/8/03	677008	4814530	11	3	1695	1.5	49	5.3	0.15	0	33	55	38	0	0.6
East Fork Big Wood River	8/6/03	718051	4833027	11	4	1775	1.8	293	9.9	0.15	2	52	34	34	1	0.1
Friedman Creek, lower	8/13/03	266125	4821885	12	3	1829	1.8	159	4.2	0.16	18	43	30	16	1	0.8
Friedman Creek, upper	8/13/03	267929	4824027	12	2	1916	2.2	159	3.4	0.09	3	50	38	5	3	1.3
Big Wood River	9/16/03	714026	4829359	11	5	1678	0.7	172	23.3	0.37	5	27	63	3	2	NA
Iron Mine Creek	9/10/03	279322	4824078	12	2	1887	2.8	217	3.2	0.08	7	47	18	26	0	0.7
Muldoon Creek	9/16/03	258542	4820336	12	3	1706	0.8	202	4.2	0.16	7	42	45	17	48	0.4
Westernhorne Gulch	9/25/03	688282	4861416	11	1	2278	5.1	191	1.7	0.05	2	54	19	2	0	0.8

^aStream order determined at the 1:100,000 scale^bAlso sampled on 2/28/2004

selection forces may be different between sexes (Roff, 1992). These guidelines were not appropriate for age at maturity characterization because there was no age overlap in immature and mature fish for males or females. Instead, we simply reported the percent of each sex that was mature at each age.

Following Robson and Chapman (1961), we estimated total annual survival rate (S) and 95% CIs using catch curves. Based on the results of the catch curves, it appeared that only age-2 and older sculpin were fully recruited to the electrofishing gear and thus useable for survival estimates. We assumed that capture efficiency was equivalent for sculpin age-2 and older. For comparison and to test this assumption we also estimated S using only sculpin age-3 and older. Growth was assessed by calculating mean length at age (and 95% CIs) following DeVries and Frie (1996).

Because gender could not be definitively determined for younger fish sampled in the summer, all fish collected in the summer ($n = 577$) were pooled to fit a von Bertalanffy growth function to the growth estimates, following the formula:

$$L_t = L_{\infty} [1 - e^{-K(t-t_0)}]$$

where L_t is length at age t , L_{∞} is maximum length, K is the growth coefficient, t is age in years, and t_0 is the time in years when length = 0.

We assessed whether any stream characteristics that we measured were correlated to survival and growth estimates for *C. leiopomus* obtained from summer sampling sites ($n = 10$). To do this, we first plotted the independent variables against survival and growth to assess whether any relationships appeared non-linear and to look for data abnormalities, but no obvious nonlinearity or abnormalities were apparent. Multicollinearity between independent variables was assessed with correlation analyses after removing from consideration any combination of independent variables with bivariate correlations greater than 0.70 (Tabachnick and Fidell, 1989); depth and stream order were highly correlated ($r > 0.70$) with several other variables and thus were removed from consideration, but no other elevated correlations were encountered. To reduce the number of independent variables we only included two substrate categories in our correlation analyses (silt and gravel).

We first assessed the relationship between stream attributes and growth and survival using simple correlation coefficients (r). To assess whether stream attributes were correlated with growth of young *C. leiopomus* differently than older fish, we related growth of both age-1 and age-3 fish to stream characteristics. To control experimentwise Type-I error at $\alpha = 0.05$, we also related independent variables (stream attributes) to a response set of variables (survival and length at age-1) using canonical correlation analysis. We explored which combination of independent variables produced a canonical correlation different than zero. We did not include length at age-3 in order to reduce the number of variables in the model, and because the correlation values were lower than for length at age-1. We avoided more complicated analyses because our sample sizes were small ($n = 10$), and because fish-habitat models often have low predictive ability or low transferability to different times or places (Fausch et al., 1988; Dunham et al., 2002). We therefore are cautious in interpreting correlations we observed as being necessarily causative.

Table 2. Correlation Coefficients (r) between Several Stream Attributes and Survival and Growth of *Cottus leiopomus* at Study Sites in the Wood River Basin, Idaho.

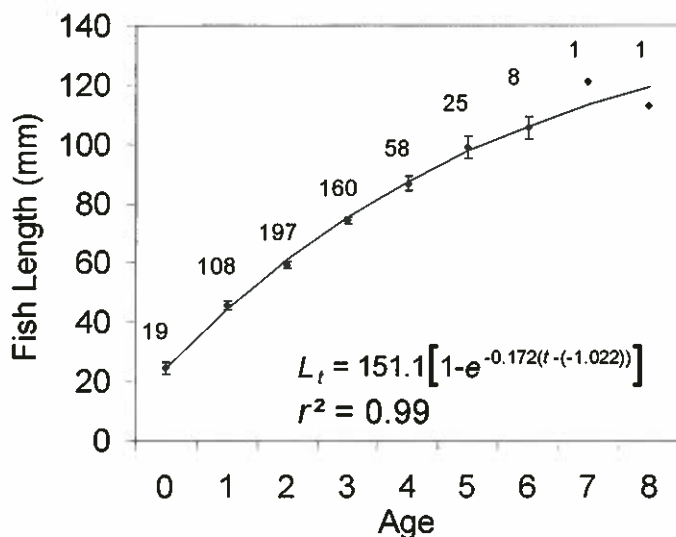
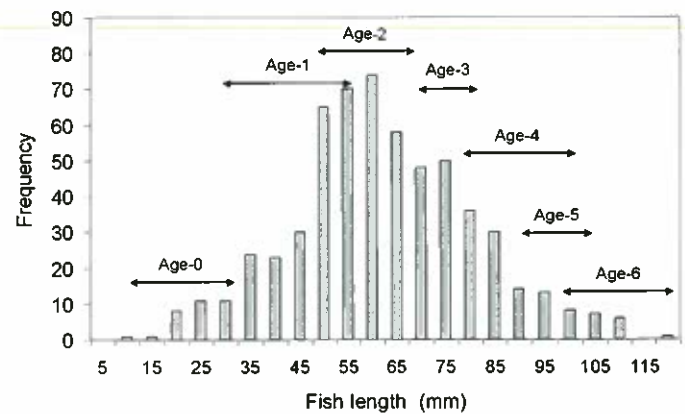
Stream variable	Survival	Growth	
		Age-1	Age-3
Elevation (m)	-0.39	-0.43	0.09
Gradient (%)	-0.66	-0.47	0.12
Conductivity ($\mu\text{S}/\text{cm}$)	0.13	-0.41	-0.33
Width (m)	0.55	0.39	-0.19
Percent silt	-0.24	0.45	-0.32
Percent gravel	-0.43	-0.56	-0.21
Percent shading	-0.16	0.00	0.00
<i>C. leiopomus</i> density (no./m ²)	-0.27	-0.10	-0.03

RESULTS

Of the 716 *C. leiopomus* whose age could be estimated, most were projected to be age-1 (16%), age-2 (33%), age-3 (30%), or age-4 (12%). Only 11 fish (<2%) were estimated to be age-6 and older; the oldest sculpin was estimated to be age-8 at Soldier Creek. Five of the ten study sites contained no fish that were estimated to be older than age-4.

Estimated total annual survival rate (S) was very consistent across all sites, averaging 66% and ranging from a low of 56% ($\pm 6\%$) at Iron Mine Creek to a high of 70% ($\pm 6\%$) at Warm Springs Creek. Had we only used age-3 and older sculpin to estimate survival, S would have been only slightly lower on average (mean 60%, range 53 to 74%). Estimated total annual survival at the study sites (from summer sampling only) was positively correlated with width and negatively correlated with gradient (Table 2). Conductivity and percent stream shading had the weakest correlations with sculpin S .

Growth of *C. leiopomus* declined with increasing size (Fig. 1). On average, sculpin reached 60 mm by age-2 and

**Fig. 1.** Mean lengths at age (and 95% confidence intervals, CIs) for all *Cottus leiopomus* combined from ten summertime study sites in the Wood River basin, Idaho. The equation and curve are for a von Bertalanffy growth function calculated from the mean lengths at age. Numbers above each data point indicate the sample size from which the means were calculated.**Fig. 2.** Length frequency and corresponding range of ages for all *Cottus leiopomus* captured during the summer ($n = 577$) in the Wood River basin, Idaho.

90 mm by age-4. Most fish (74%) were between 50 and 90 mm TL, and less than 4% were >100 mm (Fig. 2); the largest captured was 121 mm. The von Bertalanffy growth function parameter estimates for all sculpin combined were $L_{\infty} = 151.1$, $K = 0.172$, and $t_0 = -1.022$ (Fig. 1). Comparing growth of male and female sculpin from the two sites sampled in the winter (when sex could be most definitively determined), males were larger than females for all five comparisons where $n \geq 5$ for both sexes, but in only one comparison did the 95% CIs not overlap (Table 3). For age-1 *C. leiopomus*, percent silt substrate was positively correlated and gradient and percent gravel substrate were negatively correlated to mean length at age (Table 2). Percent stream shading and sculpin density were weakly correlated to age-1 mean length at age. In comparison, all stream variables were weakly correlated to growth of age-3 fish (Table 2). Canonical correlation analysis indicated that stream gradient and percent fine substrate was the only combination of independent variables that produced a canonical correlation with survival and growth that was statistically different from zero (Wilk's Lambda, $P = 0.03$).

Sex ratio was near 50:50 for most populations. The proportion of the population that was female averaged 51% ($\pm 4\%$) and ranged from a low of 39% ($\pm 14\%$) in the East Fork Big Wood River to a high of 71% ($\pm 15\%$) in Iron Mine Creek. At only two locations (Iron Mine Creek and the lower Friedman Creek site) did the 95% CIs around the estimate of the proportion of the population that was female not include 50%. Total length (mm) and weight (g) were highly correlated ($g = 0.00001 \cdot \text{TL}^{3.071}$, $n = 733$, $r^2 = 0.98$) and fit a curvilinear regression.

The length- and age-fecundity relationships were linear (Fig. 3), with length explaining much more of the variation in fecundity ($r^2 = 0.67$) than age ($r^2 = 0.34$). Fecundity ranged from a low of 38 eggs in a 58 mm age-2 fish to a high of 314 eggs in an 86 mm age-4 fish. Mean fecundity by age for all fish combined was 99 for age-2 fish ($n = 8$), 123 for age-3 ($n = 30$), and 164 for age-4 ($n = 5$).

Where winter sampling occurred (Warm Springs Creek and Trail Creek) and maturity could be more definitively determined, nearly all (98%) age-3 and older fish were mature, regardless of gender. No age-1 sculpin were mature, and no age-2 male sculpin were mature, but 71% ($\pm 24\%$) of age-2 female sculpin were mature. For females, there was no overlap between the largest immature and smallest mature fish for either Warm Springs Creek (53 and 58 mm) or Trail

Table 3. Mean Length at Age for Male and Female *Cottus leiopomus* from Two Study Sites Sampled in February 2004 in the Wood River Basin, Idaho.

Age	Warm Springs Creek						Trail Creek					
	Male			Female			Male			Female		
	Mean	± 95% CI	n	Mean	± 95% CI	n	Mean	± 95% CI	n	Mean	± 95% CI	n
2	67.0	6.0	5	64.8	5.3	12	52.5	2.0	11	48.6	1.7	9
3	73.5	2.2	15	73.2	2.4	13	71.2	3.3	13	65.7	2.5	17
4	85.4	3.5	16	83.4	5.7	5	81.6	5.8	8	86.0	—	1
5	98.3	7.2	4	102.0	—	1	94.0	—	1	83.0	—	1
6	113.0	—	1									

Creek (53 and 57 mm), whereas for males there was overlap between the largest immature and smallest mature fish for both Warm Springs Creek (74 and 62 mm) and Trail Creek (68 and 61 mm; Fig. 4). Maturity transition points for Warm Springs Creek and Trail Creek were almost identical for both genders, with females transitioning from immature to mature at 56 mm and 55 mm, respectively, compared to 62 mm for males at both locations (Fig. 4). Once the

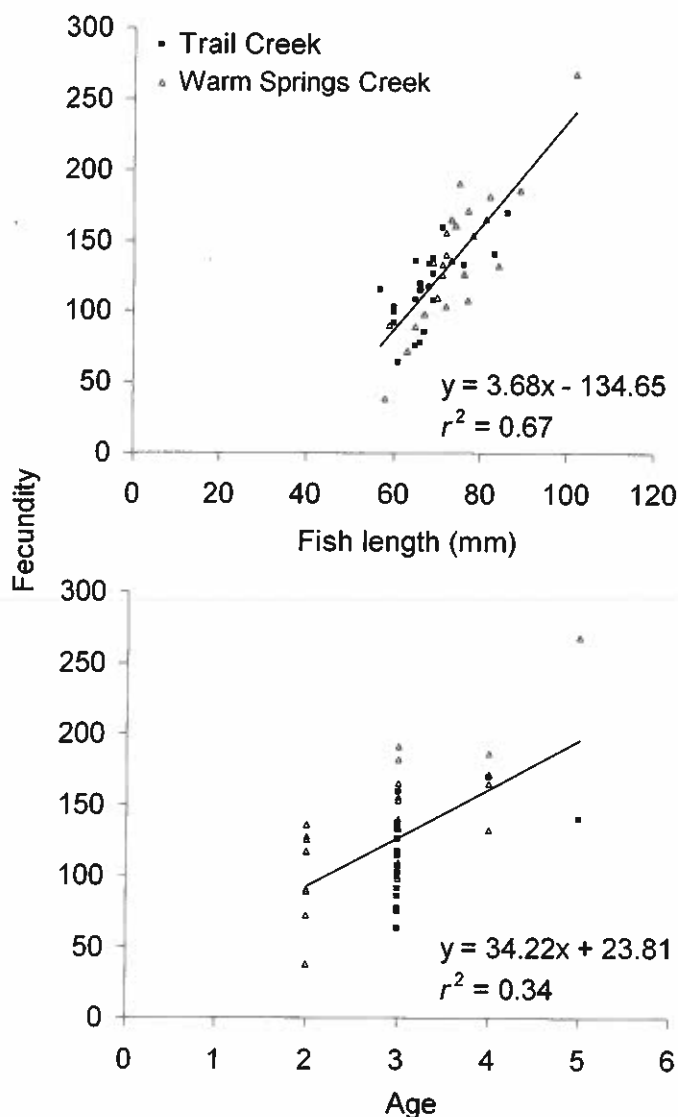
transition occurred, nearly all fish appeared ripe, suggesting that mature fish spawned every year.

DISCUSSION

Our results demonstrate that *C. leiopomus* on average live to be about six years old, reach sexual maturity in the spring by about three years of age and 60 mm in length, have a 50:50 sex ratio, grow to 100 mm by age five, and rarely exceed 120 mm. Based on these characteristics, *C. leiopomus* appear to be demographically similar to other stream-dwelling species of sculpin in Idaho, such as Shorthead Sculpin *C. confusus*, Piute Sculpin *C. beldingi*, Mottled Sculpin *C. bairdi*, and Slimy Sculpin *C. cognatus* (Zarbock, 1951; Bailey, 1952; Patten, 1971; Craig and Wells, 1976; Gasser et al., 1981). Not surprisingly, *C. leiopomus* are taxonomically more closely related to these species than many other species of sculpin in western North America (Bailey and Bond, 1963).

The consistency we saw in estimates of *S*, which ranged only from 56 to 70% among the ten populations we sampled, and with 95% CIs overlapping for all but three populations, could be caused by stream and environmental conditions being relatively similar between all streams during this study. However, most of the stream characteristics we measured at our study sites varied substantially, with examples of 7-fold, 12-fold, and 14-fold differences in conductivity, gradient, and stream width, respectively. It should be noted that our estimates of *S* are based on four or more age classes for less than half (42%) of the estimates, although the consistency in estimates across sites suggests that the results are valid.

We are cautious in drawing conclusions about what effects stream conditions may have had on survival or growth of *C. leiopomus* because sample sizes in this study were too small to fully test these effects with formal statistical analyses. Instead we relied largely on correlation coefficients, which do not necessarily equate to causation and which do not control for Type I error when numerous independent and dependent correlations are assessed. However, if the correlations we observed do confer some meaning, our results suggest that *C. leiopomus* survived better and grew faster in larger, lower elevation streams with lower gradient. Similarly, growth for age-1 fish was negatively associated with stream gradient, and was positively associated with finer substrate. These same conditions were correlated with higher sculpin density as well (KAM, unpubl. data). At a minimum, our canonical correlation analysis suggests that survival and growth decreased as gradient increased, and as percent fine substrate increased, survival decreased but growth increased. However, other work has shown that populations dynamics of *C. bairdi* were regulated most

**Fig. 3.** Relationships between fecundity and the length and age of *Cottus leiopomus* in the Wood River basin, Idaho.

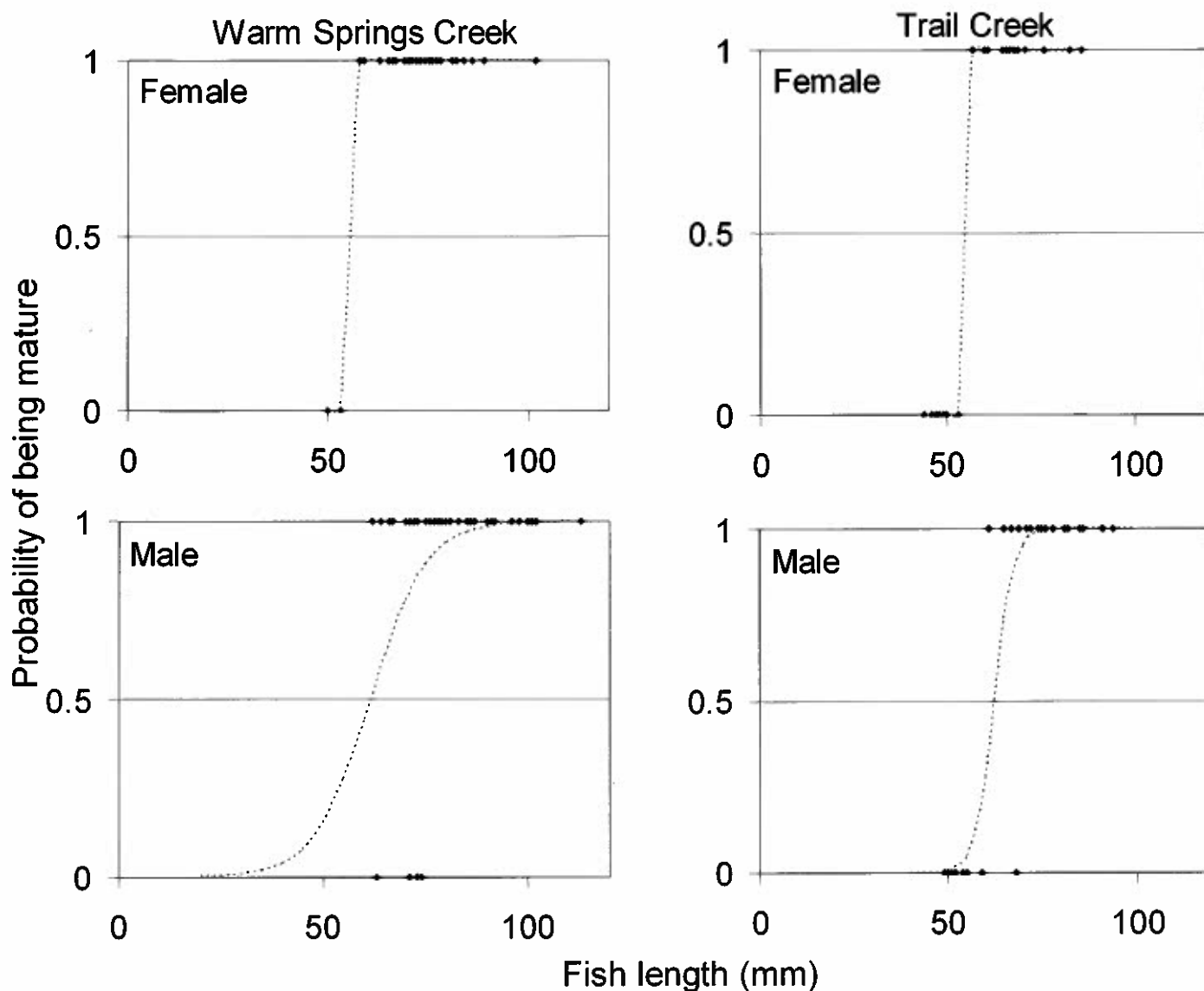


Fig. 4. Relationships between fish length and maturity for male and female *Cottus leiopomus* in the Wood River basin, Idaho.

strongly by density dependent processes such as competition for food (Petty and Grossman, 1996) and space (Grossman et al., 2006), suggesting that microhabitat and macrohabitat conditions were of much less importance for stream-dwelling sculpin.

Longevity appeared to be related to stream size. For the five streams that were <5 m wide, we never encountered fish older than age-4, whereas for the five streams that were >5 m wide, the oldest fish in the population ranged from age-5 to age-8. Our maximum age of eight years is equivalent to the longevity found in Siberian Sculpin *Cottus poecilopus* by Hesthagen et al. (2004), but is slightly older than other studies on stream-dwelling sculpin of which we are aware, which typically have found a maximum age of six or seven years (Craig and Wells, 1976; Gasser et al., 1981; Grossman et al., 2002).

The pattern we observed of increased survival and longevity in lower-gradient, larger streams could have been caused in part by movement of younger fish from headwater streams to lower elevations as they grew older. Such movements would produce higher survival estimates in lower-gradient, larger streams not because survival actually

was higher, but because small sculpin moved downstream as they got older and larger. However, such movements would result in negative correlations between densities of small fish and stream size, whereas we found that densities of sculpin < 60 mm were positively correlated to stream width ($r = 0.24$). In addition, studies of movement by stream-dwelling sculpin suggest that such a magnitude of movement is not likely (Hill and Grossman, 1987; Petty and Grossman, 2004).

Male *C. leiopomus* tended to be slightly larger than females, although this difference was statistically significant only for age-2 fish at Trail Creek. Males were larger than females for *C. beldingi* in California (Jones, 1972) and for *C. bairdi* and *C. cognatus* in Michigan (Anderson, 1985). Conversely, female *C. leiopomus* matured at a slightly smaller size and earlier age than males. We could find no other gender-specific size at maturity data for stream-dwelling sculpin for comparison, but for other stream-dwelling fish in western North America, such as trout (Meyer et al., 2003, 2006), whitefish (Wydoski, 2001), minnows (Parker et al., 1995), and suckers (Dauble, 1980), males often mature at an earlier age and smaller size.

We also found that the transition from immature to mature occurred quickly for both genders. Indeed, no age-1 *C. leiopomus* were mature, but by age-3 almost all (98%) were mature. This transition was slightly later in life and slower for *C. cognatus*, which matured in an Alaska stream at ages 3 and 4 but were not entirely mature until age-6 (Craig and Wells, 1976). Female *C. bairdi* in Montana transitioned from immature to mature at about 65 mm (Bailey, 1952), compared to our finding of a transition at about 56 mm. Our results suggest that, for both males and females, once fish reach maturity, they spawn every year. Similarly, *C. confusus* also appear to spawn annually in Idaho (Gasser et al., 1981). We caution that these maturity findings stem from only two stream locations. Clearly, more data are needed from a variety of study sites to assess whether these findings hold true elsewhere, and to more fully assess what factors affect size and age at maturity and other reproductive characteristics for *C. leiopomus*.

Taken together, it appears that life history characteristics of *C. leiopomus* are similar to most other stream-dwelling sculpin in western North America. Survival is high, almost all fish are mature by age-3, and longevity is usually age-5 and older, offering multiple chances for reproduction for each cohort. Nevertheless, considerably more work may be needed to fully describe the life history characteristics and requirements of *C. leiopomus*, and to further assess what factors may influence the variation observed in these parameters. Such findings would only serve to better protect and preserve this endemic species.

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